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JAMAICA BAY, NEW YORK. AN INVESTIGATION OF THE EFFECTS OF HURRICANE SURGE CONTROL STRUCTURES ON WATER QUALITY OF JAMAICA BAY

Public Health Service
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NEW YORK

An Investigation of the Effects of Hurricane Surge Control Structures on Water Quality

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DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service, Region II
New York, New York

In Cooperation with the

DEPARTMENT OF THE ARMY
U. S. Army Engineer District - New York, New York

JUNE 1963

JAMAICA BAY

Investigation of the Effects of Hurricane Surge Control Structures on the Water Quality of Jamaica Bay.

Prepared at the request of and in cooperation with the District Engineer, New York District, Corps of Engineers, U. S. Army.

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
DIVISION OF WATER SUPPLY AND POLLUTION CONTROL

Technical, Advisory and Investigations Section
Technical Services Branch
Robert A. Taft Sanitary Engineering Center
Cincinnati, Ohio

and

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INTRODUCTION

Jamaica Bay, an estuary on the southern shore of Long Island and lying partly within New York City, is surrounded by densely populated areas. Because of property damage associated with extreme tides due to the close passage of large storms, consideration is being given to the construction of hurricane barriers to moderate the extreme storm surges. Since each hurricane barrier plan includes features which alter the natural hydraulic regime, it is possible that the water quality of the system may be altered by the implementation of any such plan. It is necessary as part of the initial study of possible schemes to evaluate the effects of each scheme on the water quality of the system.

The New York District, Corps of Engineers, in a letter dated February 18, 1963, requested that the Public Health Service evaluate the effects of several alternative hurricane surge control plans for Jamaica Bay on the water quality of Jamaica Bay and the adjacent waters, and that this investigation be conducted on a reimbursable basis and be confined to the information presently available relative to the problem.

This report presents the results of the requested evaluation.

Numerous possible hurricane surge control schemes were considered. The New York District Corps of Engineers requested that the potential water quality associated with six of these plans be evaluated. The general descriptions of each plan are given here.

Plan A consists of the building of a permanent hurricane barrier in Rockaway Inlet with a 300-foot wide permanent gap and the development of a 25-foot deep navigation channel.

Plan B consists of the building of a permanent hurricane barrier in Rockaway Inlet with a permanent gap of 300 feet, temporarily closable to 150 feet, and the development of a navigation channel with a depth of 40 feet.

Plan C consists of the cutting of a new inlet to Jamaica Bay through Norton Basin. The new inlet would have a control depth of 42 feet and be 400 feet wide with a constriction at one point to 300 feet.

Plan D consists of the combination of Plan A and Plan C.

Plan E consists of the building of a permanent hurricane barrier in Rockaway Inlet with a permanent navigation gap 600 feet wide, temporarily closable to 300 feet, and a channel 40 feet deep.

Plan F consists of the building of a permanent hurricane barrier in Rockaway Inlet with a permanent navigation gap 1,000 feet wide, temporarily closable to 300 feet, and a channel 40 feet deep.

Each of the above barrier plans will involve the construction of a sea wall along the ocean front and an interior dike to tie in

with high ground. Other plans under consideration by the Corps of Engineers which do not involve a barrier at the mouth of Jamaica Bay include construction of small hurricane barriers across the mouths of some of the small coves in Jamaica Bay.

The location of the hurricane barrier across Rockaway Inlet and the location of the new navigation inlet are shown in Figure 1.

SUMMARY AND CONCLUSIONS

(1) The data available on the water quality of Jamaica Bay indicate that the present variations in water quality are closely related to the supply of nutrients available to aquatic plants.

(2) None of the available data are adequate measures of the nutrient supply in the system. In general, effluents from sewage treatment plants are quite high in nutrient materials; it may be expected, therefore, with the supply of nutrients to the system is closely associated with the quantities of waste entering Jamaica Bay.

(3) The data available show variations associated with changes in the tidal range in Jamaica Bay. It is postulated that this association is due to differences in flushing characteristics related to changes in the tidal prism.

(4) The BOD data are, therefore, used to develop a mathematical model incorporating the observed variations in BOD, the postulated flushing relationship to the tidal prism, and the total waste loads entering the system.

(5) This mathematical model is used to predict from changes in tidal prism the percentage changes in BOD which are assumed to reflect percentage changes in the waste load accumulated in the system and therefore changes in the nutrient supply within the system.

(6) The major effect of each hurricane barrier plan is assumed to be its effect on the tidal prism. No other effects are considered in this report.

(7) The effects of each of six hurricane surge control plans were considered in detail. The placing of barriers across some of the small boat basins will undoubtedly be detrimental to water quality within the basins. There is no information with which to evaluate the extent of these damages. The evaluation of each plan is based upon its effects upon the over-all water quality of Jamaica Bay and Rockaway Inlet. The plans considered are: Plan A - 300-foot permanent gap, 25-foot deep channel in Rockaway Inlet; Plan B - 300 foot gap, temporarily closable to 150 feet, 40-foot deep channel; Plan C - Navigation Inlet through Norton Basin, 400/300-foot wide channel, 42-feet deep; Plan D - Combination of Plan A and Plan C; Plan E - 600-foot permanent gap, temporarily closable to 300 feet, 40-foot deep channel in Rockaway Inlet; Plan F - 1000-foot permanent gap, temporarily closable to 300 feet, 40-foot deep channel in Rockaway Inlet.

(8) The analyses upon which this report is based showed that five of the six plans are slightly detrimental to water quality <u>within Jamaica Bay</u> under future loads. The changes in water quality as calculated, however, are so slight as to be regarded as negligible. Each of these

six plans is therefore acceptable from this standpoint.

(9) In Rockaway Inlet, the accumulation of waste is approximately doubled with anticipated future loads for Plan A, and is increased by about 40 per cent under Plan B and Plan C. It is not known how seriously this increase in waste accumulation will affect water use in this area. Since, however, the range of values predicted under Plan B and Plan C are within the present observed and accepted range, the resulting water quality is comparable to that at present. Plan A would result in a water quality which may be severely depressed from present quality.

(10) From the estimated future conditions in Jamaica Bay and in Rockaway Inlet, the six hurricane barrier plans are evaluated in this manner:

(a) Plan A would result in possible severe damage to water quality in Rockaway Inlet and is not recommended.

(b) Plans B, C, and D would result in a probable small deterioration of water quality in Jamaica Bay and in Rockaway Inlet, but the amount of deterioration would not be so great as to rule these plans out of consideration at this time.

(c) Plans E and F would result in little or no deterioration of water quality in Jamaica Bay which should not be detrimental to present and anticipated future water uses.

(11) The information upon which this report is based is not sufficient to permit a precise evaluation of the effects of each hurricane barrier plan considered.

(12) Detailed information about the dispersal of wastes within Jamaica Bay, the quantities of wastes entering and leaving Jamaica Bay through Rockaway Inlet and parameters reflecting nutrient build-up within Jamaica Bay are essential if a more detailed evaluation of hurricane barrier projects is required. Some of the needed information can be obtained only by hydraulic model studies.

(13) Further design studies of the effects of hurricane barriers on water quality in the Jamaica Bay system should include intensive hydraulic model studies and probably prototype field studies to obtain more detailed information on the environmental changes associated with these projects.

ACKNOWLEDGMENTS

This report is based entirely upon publications of the U. S. Coast and Geodetic Survey and upon unpublished data and reports supplied by agencies of the City of New York.

The Public Health Service particularly expresses appreciation to the New York City Department of Public Works and the New York City Department of Health for their generous cooperation in supplying field survey data from their files and in discussing the various aspects of this problem.

DESCRIPTION OF THE AREA

In its general morphology and bathymetry Jamaica Bay appears to be a typical bar-built estuary. The shallow depths and wide expanse of marshlands, the narrow inlet to the ocean, the lack of fresh water inflow, and the generally high salinity of the Bay waters all contribute to this appearance.

In some respects, however, Jamaica Bay is an atypical member of this class. The great tidal range, over five feet under present average tidal ranges, is the most striking atypical feature. This, in turn, may be related to some man-made changes which have modified the typical bar-built character of the system. The dredging associated with the construction of Idlewild Airport and with the maintenance of the navigation channels has probably had an effect upon the dynamic structure of the system, while the proximity of the complex New York Harbor and Bight system are probably largely responsible for the extreme tidal range in Jamaica Bay.

At the present time Jamaica Bay has a somewhat circular shape overall, but the deep navigation channels, islands, and marshlands divide it into at least two narrow, elongate estuary systems. The U. S. Coast and Geodetic Survey Tidal current charts for New York Harbor show that the currents along the southern shore of the Bay are somewhat higher than those along the western shore, and that there is a nodal point representing very little tidal flow in the vicinity of the highway and railroad bridges just west of Idlewild Airport in the northern part of the Bay. More detailed current information is not available at the present time.

The area surrounding Jamaica Bay is heavily populated. The Bay itself lies almost entirely within the Boroughs of Brooklyn and Queens within New York City. The area is highly developed both residentially and industrially. There are two major airfields

bordering Jamaica Bay--Idlewild Airport and Floyd Bennett Field. During the summer the Bay and its environs are intensively used for recreational purposes.

The populated area is mostly sewered and the large majority of the wastes are highly treated. The major existing pollution problem is the discharge of untreated wastes to the Bay associated with storm runoff through combined sewers. The City of New York has planned the construction of treatment facilities for the storm water overflows; when these facilities and some corollary improvements to the sewer system are completed, waste entering Jamaica Bay from this source should be reduced 50 per cent at a cost of some 40 million dollars. These improvements are directed toward increasing the potential use of Jamaica Bay as a recreational area, devoted largely to swimming and boating activities.

There are four major waste discharges from sewage treatment plants entering Jamaica Bay and Rockaway Inlet at the present time. These waste loads are listed in Table 1 and the outfall locations are shown in Figure 1. There are also three smaller sewage treatment plant discharges entering Jamaica Bay. These are from Cedarhurst, Floyd Bennett Field, and Fort Tilden; these waste loads are quite small in magnitude and are not considered further in this report. In Table 1 are also presented the estimated future waste discharges anticipated by the City of New York from the four major waste discharges.

Table 1

Major Waste Loads Discharged to
Jamaica Bay and Rockaway Inlet

Name of Plant	Treatment Type	Load Discharged (lbs BOD/day) Present	Future
Jamaica	Activated Sludge	7,000	5,800
Rockaway	Activated Sludge	1,000	5,200
26th Ward	Activated Sludge	13,300	9,200
Coney Island	Chemical (Present)	15,000	16,500
	Activated Sludge (Future)		
Total	Directly to Jamaica Bay	21,300	20,200
Total	Directly to Rockaway Inlet	15,000	16,500

Consultants in a report* to the City of New York estimate that about 3 per cent of the total sanitary sewage flow during the summer months enters Jamaica Bay mingled with storm water. At present volumes of waste loadings to the sewage treatment plants, this is equivalent to a sustained loading in the range of 4,000 pounds of 5 day 20°C BOD per day.

It should be noted, with respect to the quantity of sewage discharged through combined sewers due to storm water overflows,

*Greeley and Hansen, Engineers, "Report on Elimination of Marginal Pollution Jamaica Bay to the Department of Public Works The City of New York." March 1959.

that there is very little reliable information on the quantities which may be discharged in any particular situation. While the estimate in the preceding paragraph appears to be low, there is no evidence to suggest a better average figure for this system.*

PRESENTATION OF DATA

The data upon which this report is based consist primarily of the unpublished results from samples taken by the New York City Department of Public Works during routine summer sampling programs during the years 1959-1962. During the period from June to September about 13 samples were taken each year from each of six sampling stations as shown in Figure 1. The dissolved oxygen, temperature, and biochemical oxygen demand data from these samples are the field parameters upon which this report is based.

Table 2 is a summary showing the means of BOD and DO (as per cent saturation) at each station for the period 1959-1962 tabulated according to tide range for the day of sampling. The mean values for the stations in Jamaica Bay are also presented in this table. Tide range data were obtained from C. & G. S. Tide Tables for the appropriate years.

*A discussion of quantities of sewage discharged in storm water overflows is given by Harold Romer and Lester M. Klashman, "How Combined Sewers Affect Water Pollution," Public Works 94, p 88. April 1963.

Table 2

BOD & DO Sampling Results
1959-1962 - Summer Months

Tide* Range (ft.)	Jamaica Bay Mean Tide Range (ft.)	Station	DO (% sat.)	BOD_5 (ppm)
3.0-3.45	3.67	C	71	2.3
		J-1	78	1.2
		J-2	69	1.4
		J-3	64	1.4
		J-5	64	1.4
		J-7	46	2.2
		Mean**	64.2	1.52
3.5-3.95	4.24	C	98	1.8
		J-1	96	2.1
		J-2	89	2.8
		J-3	79	2.7
		J-5	90	1.9
		J-7	57	2.8
		Mean**	82.2	2.46
4.0-4.45	4.80	C	85	2.5
		J-1	86	1.7
		J-2	84	2.4
		J-3	69	2.1
		J-5	81	2.8
		J-7	70	3.0
		Mean**	78.0	2.40

Table 2 (Con't.)

Tide* Range (ft.)	Jamaica Bay Mean Tide Range (ft.)	Station	DO (% sat.)	BOD_5 (ppm)
4.5-4.95	5.37	C	87	1.9
		J-1	83	1.6
		J-2	77	2.0
		J-3	66	1.6
		J-5	72	1.9
		J-7	58	3.0
		Mean**	71.2	2.02
5.0-5.45	5.93	C	83	1.6
		J-1	79	1.2
		J-2	73	1.3
		J-3	63	1.1
		J-5	69	1.6
		J-7	54	2.1
		Mean**	67.6	1.46
5.5-5.95	6.50	C	83	1.8
		J-1	81	1.5
		J-2	71	2.0
		J-3	63	1.7
		J-5	70	1.8
		J-7	53	2.3
		Mean**	67.6	1.86

Table 2 (Con't.)

Tide* Range (ft.)	Jamaica Bay Mean Tide Range (ft.)	Station	DO (% sat.)	BOD_5 (ppm)
6.0-6.45	7.05	C	92	1.5
		J-1	84	1.2
		J-2	71	2.0
		J-3	60	2.1
		J-5	77	1.6
		J-7	65	3.0
		Mean**	71.4	1.98

* Tide Range at Sandy Hook

** Mean of J-1, J-2, J-3, J-5, J-7

The report of Tippetts-Abbett-McCarthy-Stratton (T.A.M.S.) to the Corps of Engineers, dated January 1963,* was the source for information on the effects of each Hurricane Barrier Plan on the tidal range and tidal prism of Jamaica Bay. Table 3 presents some of the tide-related parameters calculated from information in this report.

Information on waste discharges to Jamaica Bay and Rockaway Inlet was provided by the New York City Department of Public Works from unpublished information. These data have been presented in Table 1.

DISCUSSION

In Figure 2 the DO and BOD values presented in Table 2 are plotted for each station as functions of tide range. Because of the similarity among these curves for each station, the arithmetic means for all stations in Jamaica Bay were calculated and plotted in Figure 3(a) as functions of tide range. The values for Station C near the Coney Island Outfall are presented separately on Figure 3(b).

From a theoretical consideration of the processes involved, it would be expected that an increase in oxygen-consuming wastes,

*Tippetts-Abbett-McCarthy-Stratton, "Study and Report Jamaica Bay Improvements, New York City." Prepared for Corps of Engineers, U. S. Army, New York District, January, 1963.

Table 3

Tide Parameters for Jamaica Bay

Channel Modification	Tide Range (ft.)	Volume in Bay at Low Tide (10^9 cu. ft.)	Tidal Prism (10^9 cu. ft.)
Plan A	2.40	2.70	1.25
Plan B	3.65	2.39	1.97
Plan C	3.95	2.32	2.12
Plan D	5.00	2.10	2.72
Plan E	5.27	2.03	2.83
Plan F	5.63	1.97	3.06

as typified by BOD concentrations, would bring about a decrease in dissolved oxygen concentration, and that this decrease would be offset by the processes of turbulent reaeration, advection of DO, and photosynthetic DO production. As the aquatic plants responsible for photosynthetic DO production increase in numbers due to an optimal supply of nutrients, they add to the potential BOD of the system. If the BOD present is large, the change in BOD due to the plants may not be noticeable; if, however, the BOD is small, this change may be a significant part of the total BOD. The net result of the latter situation might be a close similarity between the DO and BOD changes within such a system.

The DO and BOD relationships exhibited in Figure 3 are quite significant when considered in the light of this preceding discussion. At Station C the classical BOD-DO relationship appears to exist, with an increase in BOD being associated with a decrease in DO. In Jamaica Bay itself the DO and BOD curves track each other quite closely. At the same time it is noted that the BOD values are quite low, having an over-all average of about 2.0 for all stations, while the DO measurements cover a wide range of values. The consistent similarity of the DO and BOD curves from the Jamaica Bay data makes it unlikely that the variations in the curves represent a random fluctuation in sampling or in the determination of a parameter. The obvious linear trend in BOD at Station C combined with the wide variation in values of DO and BOD at this station makes it difficult to justify any

correlation more sophisticated than the simple least squares linear regression line.

These results indicate most clearly that a very important factor affecting water quality inside Jamaica Bay is the supply of nutrients to the planktonic population. The supply of nutrients is directly related to the quantities of waste present in the Bay at any time. Sewage treatment plant effluents are quite rich in nutrient materials--nitrates and phosphates in particular. The accumulation of nutrients is related to the degree of flushing which occurs in the system as well as to the rate at which nutrients are utilized.

It is necessary, therefore, to obtain some estimate of flushing processes from the available information on the system and to relate this to the change in tidal prism brought about by the proposed hurricane barrier plans. The BOD data are chosen to accomplish this because these data are not affected by quite as many indeterminate parameters as are the DO data. From the data at Station C and those representing the mean of the stations within Jamaica Bay and from some general theoretical considerations of the tidal prism and exchange phenomena, a quasi-theoretical mathematical model of the BOD-Tidal Prism relationship of the system has been developed. The BOD values calculatable from this model are regarded as measures of the total waste load, and therefore nutrient, accumulation in Jamaica Bay.

This mathematical model consists of these equations:

$$(1)\quad K_j = \frac{(0.0802 - .012\,T_p)}{(T_p + T_L)(1-r)(10^3)}\left[L_o\,(1 - \frac{T_p}{2\,T_M}) + L_1\,\frac{(T_p)}{T_L}\right] + \frac{(T_p)}{T_M}\,K_b$$

$$(2)\quad K_c = (0.920 + 0.12\,T_p)\,K_j + \frac{(0.037 - .0199\,T_p)\,L_1}{T_p\,(1-r)(10^3)} + K_b$$

The symbols have these meanings:

K_j = BOD concentration in Jamaica Bay, ppm

K_C = BOD concentration at Station C, ppm

K_b = Background BOD concentration, ppm

T_p = Volume of Tidal Prism, $ft^3 \times 10^{-9}$

T_L = Volume of water in Jamaica Bay at low tide, $ft^3 \times 10^{-9}$

T_M = Volume of water in Jamaica Bay at mean sea level, $ft^3 \times 10^{-9}$

L_o = Waste discharge into Jamaica Bay, $\frac{\text{lbs. } BOD_5}{\text{day}}$

L_1 = Waste discharge at Coney Island outfall, $\frac{\text{lbs. } BOD_5}{\text{day}}$

r = A function of the deoxygenation rate constant = $10^{-k_1 t}$

where $k_1 = 0.10$ at 20° C

$t = 1.0$

The development of this model proceeds from these general considerations:

(1) If there were no flushing of wastes from Jamaica Bay

through Rockaway Inlet or vice versa, the total quantity of waste accumulated in the Bay would be the sum of a geometric series in which L_o is the initial term and r is a constant ratio, which is a function of the rate at which the waste decays. The first term of equation (1) has the appropriate form in the limit, since, as $T_p \longrightarrow 0$, $T_L \longrightarrow T_M$, and the term involving L_1 becomes zero.

(2) In the presence of tidal action, waste from some discharges will be advected from the system as soon as it is discharged and some of the waste discharged into Rockaway Inlet will be immediately advected into Jamaica Bay. The waste load actually present and undergoing decomposition within the Bay is directly related to these advective processes, and the term exhibiting the total waste load entering the Bay in one day must be weighted according to the magnitude of the advective processes. After a detailed consideration of the relative magnitudes and locations of the waste discharges and the volumes of water involved in the tidal exchange, it is postulated that $\frac{T_p}{2T_M}$ adequately represents the advective loss of

wastes discharged directly to Jamaica Bay, and that $\frac{T_p}{T_L}$ bears a similar relationship to the waste discharge into Rockaway Inlet.

(3) There is a change in the total waste load in Jamaica Bay due to turbulent diffusion of wastes in the volume of water involved in the tidal exchange. This is directly related to the volume of the tidal prism.

(4) There is a more or less constant background waste load due to surface runoff, direct sewage discharges, and natural processes. It is postulated that this is also related to $\frac{T_p}{T_M}$ in Jamaica Bay. After consideration of the minimum BOD concentrations observed, it was assumed that this background BOD was about 0.5 ppm under the observed conditions.

(5) The BOD at Station C, (K_c), is partially a function of K_j and the turbulent diffusion related to the tidal action.

(6) The parameter K_c also is dependent upon the geometric sum of the discharge L_o into T_p and a turbulent diffusion change different from that in Jamaica Bay, but also dependent upon the tidal prism. There is also assumed a small but constant background BOD.

This mathematical model is obviously over-simplified, but the available data are not sufficient to justify a more sophisticated model.

The mathematical model is used with the present and anticipated future waste loads to predict waste accumulations in Jamaica Bay and in Rockaway Inlet for the tidal prism estimated from the T.A.M.S. report (as cited previously) for each hurricane surge control plan. The results of these calculations are presented in Table 4.

These calculations show that any interference with flow through Rockaway Inlet will be detrimental to water quality within the Inlet itself. These results also show that changes in waste load accumulations within Jamaica Bay are very small with any of the hurricane barrier plans evaluated, in many of the cases are virtually zero.

These results indicate that a hurricane barrier in Rockaway Inlet may be beneficial to water quality in Jamaica Bay merely by keeping waste materials out of the Bay itself. This possibility may be explored a little further by estimating what the total BOD accumulated in Jamaica Bay might be in the absence of any flushing at all. If the same rate constant factor used in the previous calculations is used here, the concentration of BOD_5 in Jamaica Bay due to the three sewage treatment plant discharges is about 0.5 ppm. This indicates that a major fraction of the BOD in the system is being introduced from other sources; the Coney Island outfall is in an excellent position to be a major source of the remaining BOD.

It is informative to note that dye studies in the hydraulic model of New York Harbor* showed that simulated waste discharges from

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* "Joint Pollution Studies on the New York Harbor Model." Miscellaneous Paper 2-558 (February 1963), U. S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Table 4

Estimated Waste Load Accumulations in Jamaica Bay and Rockaway Inlet Resulting From Hurricane Barriers

Channel Modification	Waste Load Accumulation (per cent of Base condition)			
	For Present Loads		For Future Loads	
	Jamaica Bay	Rockaway Inlet	Jamaica Bay	Rockaway Inlet
None (Base Conditions)	100	100	100	100
Plan A	110	190	107	201
Plan B	99	134	104	144
Plan C	105	133	104	137
Plan D	102	114	102	116
Plan E	98	107	98	108
Plan F	100	106	101	107

several waste treatment plants in the New York complex reached Jamaica Bay in significant concentrations. The total BOD_5 concentration entering Jamaica Bay from three sewage treatment plants in New York and New Jersey is estimated at 0.3-0.4 ppm from the results of these dye studies.

While the total amount of information available on the Jamaica Bay system is not sufficient to present a quantitative estimate of the sources of waste present in Jamaica Bay and Rockaway Inlet, the available data do point out that the waste loads accumulated in Jamaica Bay come partly from areas external to the Bay. An intensive model study and possibly a prototype study would be necessary to develop the data required for a quantitative estimate of the sources of waste in Jamaica Bay and in Rockaway Inlet.

It is important to recognize that the mathematical models upon which the results presented in Table 4 are based are not sufficiently detailed to provide an appreciation of what effects hurricane barriers may have on the internal circulation of Jamaica Bay or upon the dispersal of wastes discharged into Rockaway Inlet. Both the T.A.M.S. mathematical model (as presented in the report cited) and the mathematical model presented in this report are based upon a gross appreciation of the hydraulics of the system. While it is believed that both of these models are adequate in the present stage of project investigation, a more detailed knowledge of the internal current and water mass movement regime in the system are essential if a more accurate

evaluation of these several plans is required. Hydraulic model studies are strongly recommended in this case.

The most significant feature of any plan which involves constriction of Rockaway Inlet is the potential established for the accumulation of nutrient materials in Jamaica Bay and the concomitant algal blooms which may result from such an accumulation. The available information does not provide direct evidence of present conditions related to algal blooms and die-offs in Jamaica Bay. The indirect evidence suggests that there are no serious problems of this type at the present time. Without direct evidence, however, it is necessary to exercise extreme caution in evaluating the effects of each hurricane barrier plan on biological phenomena in the system.

Table 4 shows that each plan except Plan E may result in a very slight increase of waste load accumulation in Jamaica Bay. Plan E may result in a very slight decrease. The ranges of increase or decrease associated with each plan, while indicative of trends, are so slight as to be quantitatively negligible when the data base of these calculations is considered. The significant effect of the hurricane barriers on Jamaica Bay appears to be that the decrease in flushing out of wastes discharged directly into Jamaica Bay is counterbalanced by a decrease in the influx of wastes through Rockaway Inlet.

The estimated accumulation of wastes in Rockaway Inlet outside of the barrier as presented in Table 4 illustrates the importance of the barriers in reducing the influx of waste into Jamaica Bay. An

increase of pollutional materials in this area is, however, of concern because of the proximity of intensively used recreational beach areas such as Coney Island, as well as the proposed Plumb Beach and Marine Park Beach recreational areas.

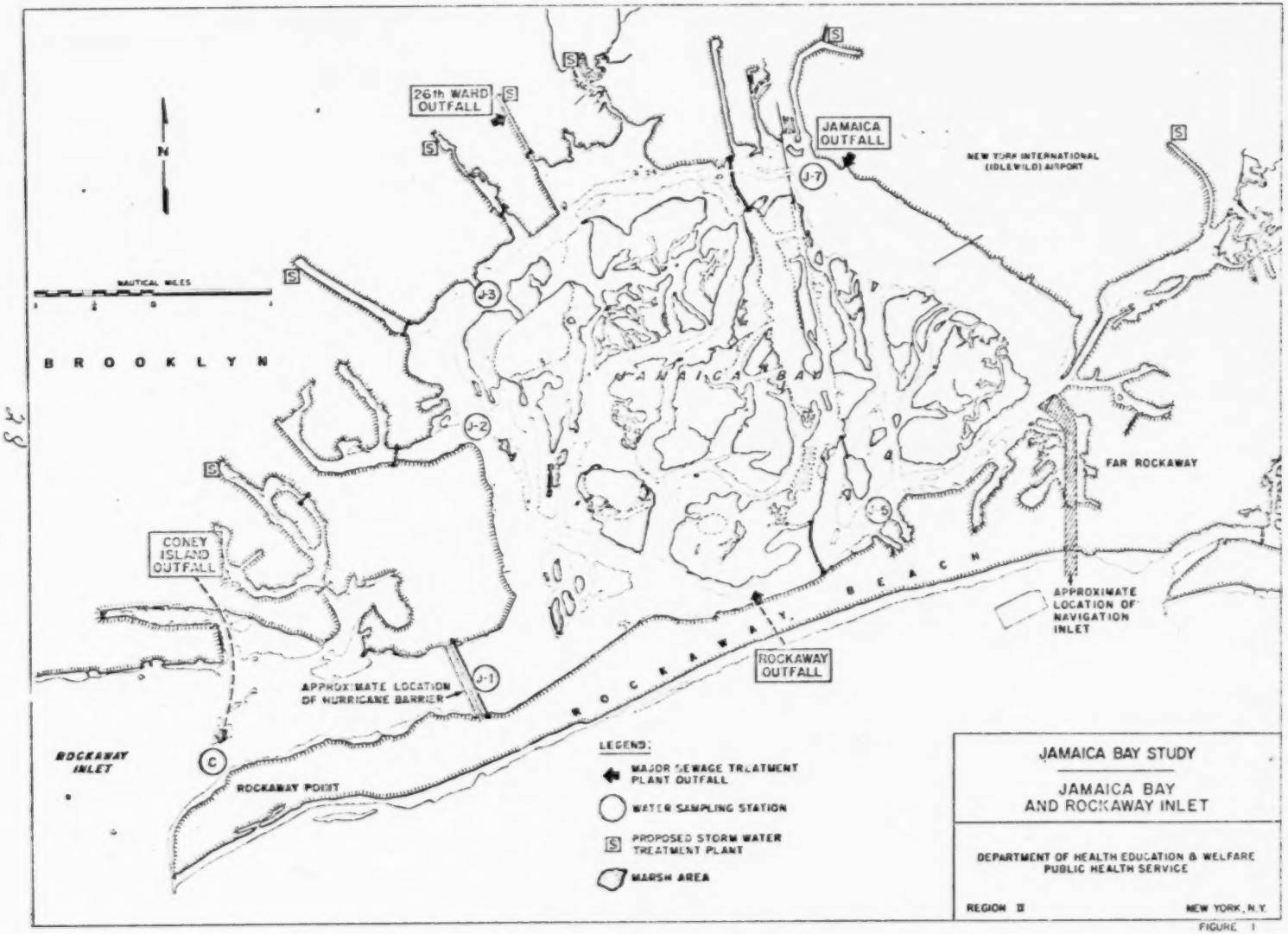
Plan A results in a doubling of the waste load accumulated in Rockaway Inlet. Experience in other estuarine regions with BOD_5 values in the range represented by this estimate indicates that there may be occasional severe DO depletion and algal blooms associated with this amount of waste accumulation. It is possible that relocation of the Coney Island outfall farther out to sea would reduce this accumulation significantly; detailed hydraulic model and prototype investigations would be necessary to determine this. The cost of such a relocation, in excess of $1,000 per lineal foot of pipe, would probably be prohibitive.

Plans B, C, and D also result in a significant increase in the accumulation of wastes in Rockaway Inlet. The magnitude of the increase associated with each of these plans is not, however, so great as to rule out their further consideration as feasible hurricane barrier projects. A potential hazard related to Plans C and D is the possible pollution of Rockaway Beach by wastes flushed out of Jamaica Bay through the new navigation inlet. The likelihood of such an occurrence could be established only by a hydraulic model study.

Plans E and F would result in a small increase in the wastes accumulated in Rockaway Inlet. The amount of this increase is not

large enough to indicate that either of these plans would result in a significant damage to water quality.

The data presently available on the Jamaica Bay system are adequate to indicate the general trends previously discussed. This gross evaluation is consistent with the survey scope of the present report. It is felt, however, that the currently available information is not adequate to permit the detailed calculations of either beneficial or adverse effects on water quality which will ultimately be required prior to the design stage of this project. Any assessments of benefits or damages would have to be based upon the reduction or increase in sewage treatment costs, the relocation of outfalls, and the benefits or losses in recreational potential in other water uses in the area. The development of the necessary data to serve as a basis for such computations would involve intensive field and model investigations of Jamaica Bay, Rockaway Inlet, and the sewage treatment plants and recreational facilities involved. Such investigations are beyond the scope of this study.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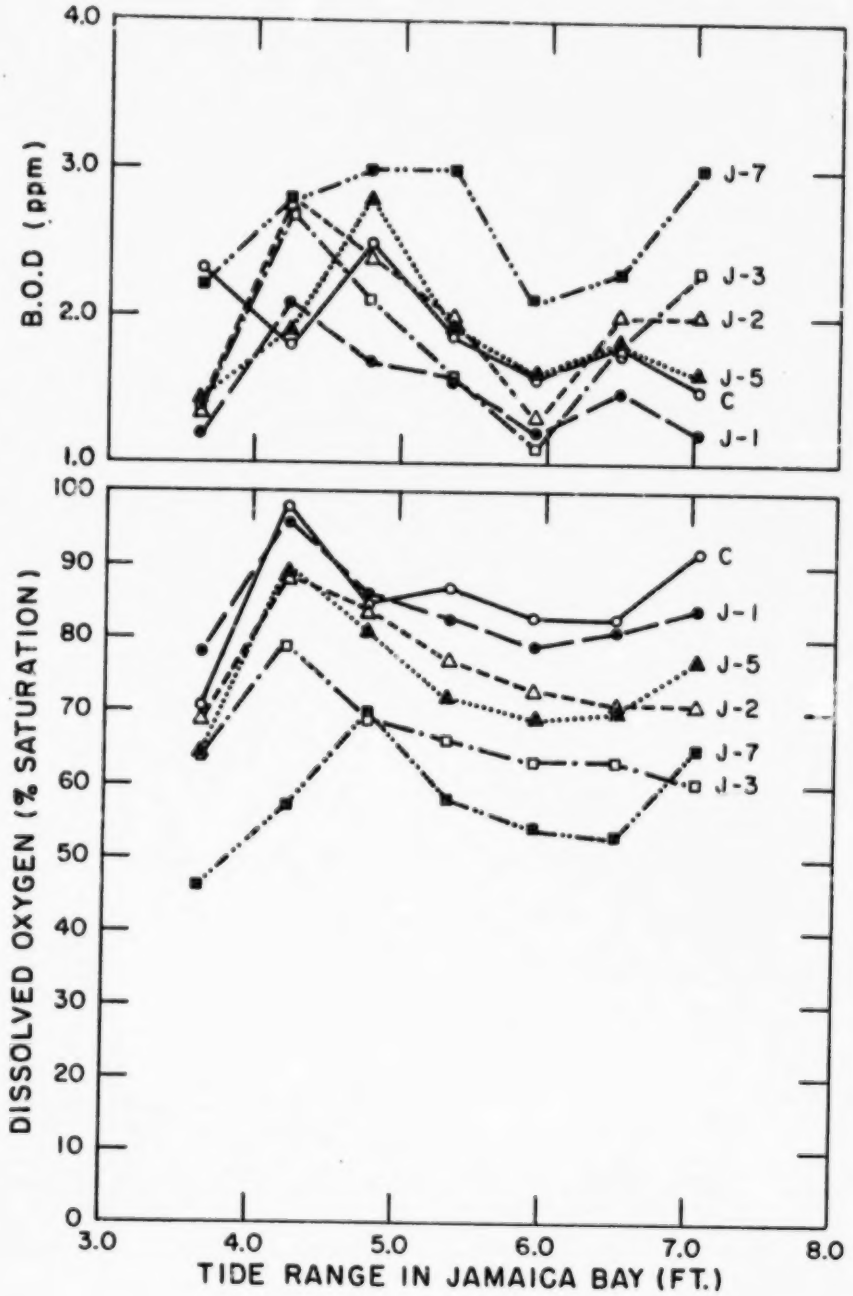
JAMAICA OUTFALL
NEW YORK INTERNATIONAL (IDLEWILD) AIRPORT
J-7
J-3
J-2
J-5
J-1
JAMAICA BAY
FAR ROCKAWAY
CONEY ISLAND OUTFALL
APPROXIMATE LOCATION OF NAVIGATION INLET
ROCKAWAY OUTFALL
ROCKAWAY BEACH
APPROXIMATE LOCATION OF HURRICANE BARRIER
ROCKAWAY INLET
ROCKAWAY POINT
LEGEND:
MAJOR SEWAGE TREATMENT PLANT OUTFALL
WATER SAMPLING STATION
PROPOSED STORM WATER TREATMENT PLANT
MARSH AREA
JAMAICA BAY STUDY
JAMAICA BAY AND ROCKAWAY INLET
DEPARTMENT OF HEALTH EDUCATION & WELFARE
PUBLIC HEALTH SERVICE
REGION II
NEW YORK, N.Y.

FIGURE 1



B.O.D. AND D.O. RESULTS AT INDIVIDUAL STATIONS AS FUNCTIONS OF TIDE RANGE

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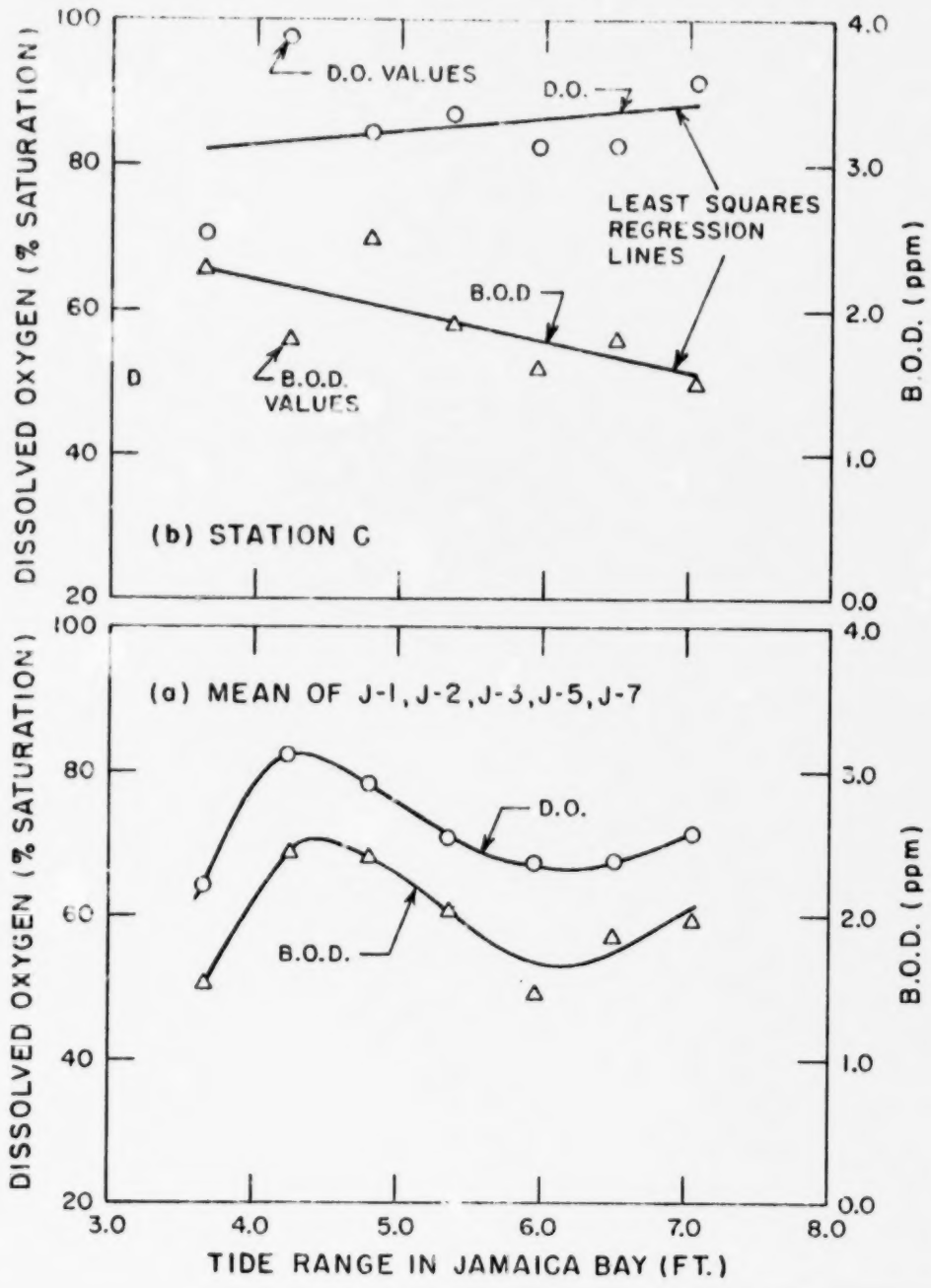
REGION II — NEW YORK, N.Y.

FIGURE 2



MEAN VALUES OF B.O.D. AND D.O.
AS FUNCTIONS OF TIDE RANGE

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FIGURE 3